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# Uniform Phosphorus Experiments in 1952



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## Foreword

In May 1952 the report, "Uniform Phosphorus Experiments: Cooperative Studies on the Fertility Status of Soils", was issued. It summarized the results of cooperative experiments undertaken in 1951. This report summarizes a parallel series of experiments conducted in 1952. These investigations have given detailed information regarding the phosphorus fertility status of more than a hundred soil samples from widely scattered locations. These soil samples and the accompanying data are now being used in a number of investigations including a comparison of soil testing methods conducted by the National Soil Test Work Group. Since there has been such extensive use of the data, the suggestion was made that these two summary reports be combined and published as a U. S. Department of Agriculture Circular. All cooperators have agreed to this proposal and it is hoped that the preparation of the publication will begin shortly.

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June 1953

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Uniform Phosphorus Experiments: Cooperative Studies on the Fertility Status of Soils

## Introduction

Many of the field and greenhouse experiments with radiophosphorus have indicated that the proportion in which the crop absorbs its phosphorus from the soil and from the fertilizer is related to the phosphorus fertility status of the soil. Fried and Dean[1] have proposed a basis for calculating the amounts of available phosphorus in soils by using the data from field or greenhouse experiments in which $P^{32}$ was used to measure the relative amounts of soil and fertilizer phosphorus absorbed by crops. Therefore, it was of interest to evaluate the usefulness of these experiments as a criterion for evaluating the phosphorus fertility status of soils.

In 1951 a series of 69 uniform phosphorus field experiments were conducted to measure the yield response to phosphorus application and the relative amounts of soil phosphorus and fertilizer phosphorus absorbed by the crop. Soil samples were collected from the sites of all field experiments and sent to Beltsville where a companion greenhouse experiment was conducted. On the basis of results obtained from these tests, a number of cooperators indicated that further work on this problem would be of value. Following the same basic outline of experimentation, a series of 36 field experiments were conducted in 1952 along with a companion greenhouse study at Beltsville. As in 1951, soil samples from the test sites were reserved for distribution to soil research laboratories.

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1/ Fried, M. and Dean, L. A. Soil Sci. 73: 262-273 (1952)

## Field Experiments

The field experiments for each of the four regions were independently planned by the respective work groups participating in the national program of field experiments with radiophosphorus. In each region a crop was selected that was considered the most satisfactory for a series of uniform phosphorus experiments within that region. The Western group selected spring barley; (in 1951 the crop was spring wheat). The North Central and Northeastern groups, oats; and the Southern group, cotton. In three instances wheat was selected. However, in several instances there were States that for reasons of climate considered it more desirable to grow the crop chosen by an adjacent region rather than their own. For this reason the field experiment results are classified by crops rather than regions.

### Methods

In order that the methods used by the various individuals would be essentially similar, recommendations regarding the experiments were cooperatively developed. These guide lines are outlined in Table 1.

### Results

The results reported from the field experiments are given in Tables 2, 3, 4 and 5. In addition to the yields and to the measured value, percent phosphorus in the crop derived from the fertilizer calculations are given for the 'A' values and the percent yield. The formula for the 'A' value can be applied in two ways resulting in slightly different answers. One is to average the percent phosphorus in the crop from the fertilizer for individual plots and calculate the 'A' value using this

mean. The other is to calculate an 'A' value for each plot and average these. The latter method was preferred because it was then possible to calculate a standard error, and was used when the data were available.

For the purpose of correlating yield response with other criteria of the phosphorus fertility it is necessary to assign numerical values that are indicative of the degree of response. Largely as a matter of convenience the percent yield method suggested by Bray was selected. It is calculated as follows:

$$\text{Percent yield} = \frac{\text{yield without phosphate fertilizer}}{\text{yield with adequate phosphate fertilizer}} \times 100$$

An examination of the yields recorded from the individual experiments revealed that there was considerable latitude of choice in values that could be selected for maximum and minimum yield. An unbiased method of selection seemed necessary. Assuming that growth response is logarithmic, a line of best fit was estimated using the yields at all rates of phosphorus application. This line then provided a basis for estimating an adjusted yield for the check and highest phosphate treatment. These two values were subsequently used to determine the percent yield.

Significant yield responses to phosphate fertilization were obtained in 2 of the 7 cotton experiments, 7 of the 12 oat experiments, 5 of the 7 barley experiments and 2 of the 3 wheat experiments. Seven crop failures were reported, the majority a result of extreme drought conditions.

'A' values in all experiments were computed for the standard rate (40 Lbs. $P_2O_5$/Acre). The standard errors for the 'A' values give some indication of their reliability. The coefficient of variation ranged from a minimum of 3.71 percent to a maximum of 18.7 percent with the

majority grouped between 9 and 13 percent. Although the standard error increases with the mean, the coefficient of variation appears to be independent of the 'A' value.

## Greenhouse Experiments

The greenhouse experiments involving the soils from all of the uniform field experiments were for the purpose of comparing the information obtained in the field with that obtainable in the greenhouse.

### Methods

A greenhouse experiment was conducted on 36 soils from uniform field experiments plus 4 soils used as greenhouse standards. The crop was German millet. The three replications were seeded on July 16, 1952 and were harvested five weeks later.

Each soil received 4 treatments, namely, 0, 40, 80 and 160 pounds $P_2O_5$ per acre. The phosphorus was applied as monocalcium phosphate which was mixed with all of the soil in each pot. The monocalcium phosphate used for all rates of application was labeled with $P^{32}$. All soils received 150 pounds nitrogen per acre as $NH_4NO_3$. The acid and neutral soils received 200 pounds $K_2O$ per acre as $K_2SO_4$, but the Western calcareous soils received only 100 pounds $K_2O$ per acre.

The pots were No. 10 cans. A constant volume of soil was used and consequently the weight of soil per pot varied from soil to soil. The actual weights used are shown in Table 9. Fertilizer applications were calculated on the basis of the surface area, 0.204 grams nutrient equaling an application of 100 pounds per acre. Ten millet plants were grown in each pot.

## Results

The yields, percent yield, and percent total phosphorus in the crop are shown in Table 6. Average yields for the 160 pound rate showed the following:

| | | | |
|---|---|---|---|
| 15 - 18 grams | = 17.95% | of soils | (7) |
| 18 - 24 " | = 64.10% | " " | (25) |
| 24 - 31 " | = 17.95% | " " | (7) |

Yields ranged from a minimum of 15.69 grams to a maximum of 30.88 grams.

Thirty-five of the 39 soils listed showed a significant yield response at the 5 percent level. When the degree of yield response is expressed as percent yield, the soils tend to fall into three groups (see Table 7); namely, those soils which show a very large yield increase resulting from phosphate fertilization 0-40 percent yield, those showing an intermediate yield increase 40-80 percent yield, and those showing a relatively small yield increase, 80-100 percent yield. This pattern is not entirely comparable to that obtained in the 1951 tests. As was true in 1951, generally, the crops grown on the untreated soils showing large yield increases had a higher percentage of phosphorus than those receiving 40 and 80 pound rates of $P_2O_5$. On the other hand, the crops grown on soils showing a moderate or no yield response show an increase in percent phosphorus with increasing rates of phosphorus fertilization.

Table 8 gives the percent of the phosphorus in the crop derived from the fertilizer for the 40 and 160 pound rates of monocalcium phosphate application and the 'A' values calculated from this information. With most soils (32), the 'A' values increased as the phosphorus rate was increased from 40 to 160 pounds.

## Correlations

In addition to the yield and 'A' value data discussed above, laboratory measurements of available phosphorus and mechanical analyses were determined on all soils (see Tables 8 and 9). Through the use of correlation analysis it is possible to study the interrelationship between the various criteria for the phosphorus fertility status of soils. From a practical standpoint, we are interested in crop yield and the prediction of the behavior of crops resulting from the use of fertilizers. However, experiments designed to measure yield changes resulting from fertilizer usage are plagued by uncontrolled variables. This greatly complicates the evaluation of soil tests.

Correlations of percentage yield for both field and greenhouse experiments with the available soil phosphorus by the 'A' value, Bray and Truog methods, along with a correlation between the greenhouse and North Carolina State Laboratory testing method, are given in Table 10. The correlations with the results from the field experiments show no significance with the Bray and Truog methods and are barely significant with the 'A' value at the five percent level. The correlations using the greenhouse yield data are highly significant with the exception of the Truog method which is significant at the five percent level, but the $r^2$ values indicate that there is still a large proportion of the variance unaccounted for.

The 'A' values determined in the field and those determined in the greenhouse are not well correlated. Five of the field determined values are extremely high. If the fertilizer is applied near the surface and

there is a dry growing season, the crop has relatively little opportunity to utilize this phosphorus. In other words, the fertilizer can be considered as being positionally unavailable, thus resulting in a high 'A' value since this is an expression of availability of the soil phosphorus relative to the fertilizer phosphorus.

A series of simple and multiple correlations with percent yield as determined in the greenhouse are given in Table 11. The percent yield consists of the ratio of the yield of check to maximum yield. Apparently the important source of variation is the yield of check.

If, for the purpose of comparison, the 'A' value determined in the greenhouse is accepted as a standard measure of the phosphorus fertility then correlations with it would be one way of evaluating the various laboratory soil tests. A comparison of such correlations is given in Table 12. There was an excellent correlation of 'A' value with the Bray method; a poor correlation with the Truog and North Carolina State Laboratory methods. However, the partial correlation coefficient 'A' value versus the Truog phosphorus and pH shows an improvement. It must be remembered that the soils comprising the group under consideration have a wide variation of properties. Some are very acid while others contain free calcium carbonate. Many of the laboratory methods for determining available phosphorus are not equally applicable over this entire range, but the 'A' value method should not be appreciably affected.

Table 1. Recommended Plans for Uniform Phosphorus Field Experiments

| | Spring Barley and Wheat | Oats | Cotton |
|---|---|---|---|
| Source of phosphate | Conc. superphosphate | Conc. superphosphate | Conc. superphosphate |
| Treatments | 1. Check<br>2. 20 lbs. $P_2O_5$/A 1/<br>3. 40 " "<br>4. 80 " " | 1. Check<br>2. 20 lbs. $P_2O_5$/A 1/<br>3. 40 " "<br>4. 80 " " | 1. Check<br>2. 10 lbs. $P_2O_5$/A 1/<br>3. 20 " "<br>4. 40 " "<br>5. 80 " " |
| Method of application | $P_2O_5$ drilled in row with seed 2/ | $P_2O_5$ drilled in row with seed 3/ | 1/4 N + $P_2O_5$ + $K_2O$ in single band 2 1/2" under seed 4/ |
| Variety | Best adapted to locality of experiment | Clinton | Best adapted to locality of experiment |
| Seeding procedure | Drill at rate of 4 pecks per acre, 2" deep | No instructions | Cotton seeded 2 1/2" deep |
| Experimental design | Randomized blocks 6 replications | Randomized blocks 6 replications | Randomized blocks 5 replications |
| Size of plots | 5 drill rows, 1' apart, by 20' long | 7 to 9 drill rows wide by 20' long | 17.5' wide (5 rows) by 30' long |
| Radioactive area | Whole plot to receive $P^{32}$ tagged fertilizer | Whole plot to receive $P^{32}$ tagged fertilizer | $P^{32}$ tagged fertilizer placed in center row only |
| Sampling for specific activity | Late dough stage, take 50 heads at random from 3 center rows of each $P^{32}$ plot | To be taken not earlier than the late dough stage | Leaves taken from middle of plants 90 days after planting |
| Harvesting | Grain and straw weights on 16' lengths of 3 center rows at maturity | No instructions | Harvest cotton from 25' length of 3 inside rows |

1/ Treatment 3 will receive $P^{32}$ if only one rate is tagged.

2/ Apply N uniformly over all plots.

3/ Apply N and $K_2O$ if likely to be limiting.

4/ Apply 80 lbs./A N and 60 lbs./A $K_2O$.

Table 2. Summary of Uniform Oat Experiments, 1952

| Ref. No. | Soil No. | State | Soil Type | Grain Yields (Bu./A) for Application of $P_2O_5$ - Lbs./A: 0 | 20 | 40 | 80 | LSD | Coeff. of Var. Percent | Percent Yield | Percent P in Plants Derived from Fertilizer Applied at 40 Lbs. $P_2O_5$/A | 'A' Value Lbs. $P_2O_5$/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 111 | 52574 | N. Dak. | Timmer L | 55.5 | 64.1 | 65.7 | 71.2 | 8.78 | 11.12 | 86.4 | 42.4 | 55 ± 7.6 |
| 112 | 52575 | " " | Langdon L | 38.8 | 52.4 | 62.3 | 63.0 | 4.84 | 7.25 | 75.2 | 53.1 | 36 ± 7.2 |
| 113 | 52571 | S. Dak. | Frankfort Si L | | Crop Failure | | | | | | | |
| 114 | 52572 | " " | Beadle Si L | 29.1 | 29.4 | 27.3 | 31.2 | N.S. | 13.41 | ---- | 14.1 | 260 ± 78 |
| 119 | 52577 | Neb. | Sharpsburg Si C | 15.1 | 16.8 | 17.1 | 17.2 | N.S. | 16.03 | ---- | 13.1 | 271 ± 39 |
| 120 | 52578 | " | Moody Si L | | Crop Failure | | | | | | | |
| 121 | 52579 | " | Holdrege Si L | | Crop Failure | | | | | | | |
| 122 | 52565 | Iowa | Monona Si L | 38.8 | 38.9 | 39.2 | 40.4 | N.S. | 5.98 | ---- | 13.2 | 272 ± 59 |
| 125 | 52568 | " | Carrington Si L | 34.9 | 45.5 | 47.6 | 50.5 | 4.76 | 8.68 | 79.6 | 43.7 | 53 ± 11 |
| 124 | 52567 | " | Edina Si L | 28.5 | 32.3 | 36.9 | 37.1 | 2.19 | 5.28 | 84.1 | 37.6 | 68 ± 12 |
| 126 | 52589 | Ill. | Muscatine Si L | 34.5 | 47.7 | 45.6 | 52.9 | 4.43 | 7.96 | 79.9 | 40.1 | 60 ± 5.7 |
| 127 | 52590 | " | Elliott Si L | 52.9 | 70.4 | 72.5 | 76.7 | 4.49 | 7.57 | 81.4 | 36.2 | 74 ± 22 |
| 118 | 52576 | Mich. | Hillside Si L | 19.3 | 25.5 | 25.7 | 26.8 | 3.03 | 9.02 | 80.2 | 35.4 | 75 ± 16 |
| 128 | 52600 | Maine | Merrimac S L | 25.5 | 24.6 | 24.3 | 28.6 | N.S. | 13.98 | ---- | 17.0 | 211 ± 77 |
| 129 | 52601 | " | Caribou Si L | 28.9 | 23.7 | 28.0 | 27.8 | N.S. | 13.77 | ---- | 5.4 | 802 ± 387 |

Table 3. Summary of Uniform Cotton Experiments, 1952

| Ref. No. | Soil No. | State | Soil Type | Seed Cotton Yields - Lbs./A for Application of $P_2O_5$: 0 | 10 | 20 | 40 | 80 | LSD | Percent Yield | Coeff. of Var. Percent | Percent P in Plants Derived from Fertilizer Applied at 40 Lbs. $P_2O_5$/A | 'A' Value Lbs. $P_2O_5$/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 131 | 52573 | S.C. | Cecil S L (Eroded Phase) | 813 | 1384 | 1377 | 1505 | 1639 | 257 | 79.2 | 13.8 | 20.9 | 157 ± 42 |
| 132 | 52597 | Ala. | Norfolk L S | 1323 | 1440 | 1432 | 1503 | 1545 | N.S. | ---- | 8.8 | 41.0 | 63 ± 25 |
| 133 | 52581 | Ga. | Lloyd C L | 775 | 775 | 758 | 787 | 815 | N.S. | ---- | 11.7 | 48.9 | 43 ± 12 |
| 134 | 52582 | " | Orangeburg S L | 1152 | 1273 | 1379 | 1251 | 1351 | N.S. | ---- | 14.6 | 36.3 | 73 ± 19 |
| 135 | 52587 | " | Madison S L | 943 | 1022 | 1034 | 1052 | 1032 | N.S. | ---- | 18.7 | 40.8 | 70 ± 40 |
| 137 | 52591 | Tex. | Norwood Si C L | | | Crop Failure | | | | | | 4.3 | 779 ± 201 |
| --- | ---- | Miss. | Hunt C | 709 | 720 | 775 | 881 | 844 | 88 | 89.9 | 9.3 | 2.6 | 1651 ± 638 |
| 116 | 52584 | " | Ecru Si L | 1238 | 1257 | 1186 | 1221 | 1221 | N.S. | ---- | 9.1 | 7.8 | 571 ± 321 |

Table 4. Summary of Uniform Barley Experiments, 1952

| Ref. No. | Soil No. | State | Soil Type | Grain Yields (Bu./A) for Application of $P_2O_5$ - Lbs./A 0 | 20 | 40 | 80 | LSD | Coeff. of Var. Percent | Percent Yield | Percent P in Plants Derived from Fertilizer Applied at 40 Lbs. P205/A | 'A' Value Lbs. $P_2O_5$/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | 52588 | Cal. | Holtville Si C | 56.4 | 61.0 | 61.1 | 60.2 | N.S. | 10.12 | ----- | 35.4 | 80 ± 31 |
| 101 | 52604 | Wash. | Sagemoor L | | Crop Failure | | | | | | | |
| 102 | 52585 | Mont. | Nunn C L | 62.9 | 64.0 | 64.7 | 70.6 | N.S. | 7.66 | ----- | 20.0 | 162 ± 21 |
| 103 | 52598 | Colo. | Cass Si L | | Crop Failure | | | | | | | |
| 104 | 52599 | " | Ft. Collins L | | Crop Failure | | | | | | | |
| 105 | 52592 | Idaho | Declo L | 42.3 | 55.5 | ---- | ---- | 8.68 | 11.96 | 76.2 | 15.5 | 111 ± 20 |
| 107 | 52602 | Ore. | Olympic Si L | 32.8 | 47.2 | 48.3 | 50.3 | 7.43 | 13.54 | 79.7 | 46.4 | 64 ± 54 |
| 109 | 52569 | N.Dak. | Cheyenne F S L | 21.8 | 26.5 | 27.1 | 25.7 | 3.07 | 9.88 | 90.8 | 19.5 | 173 ± 50 |
| 110 | 52570 | " | Huff L | 44.4 | 56.8 | 69.9 | 71.4 | 8.38 | 11.24 | 74.8 | 49.6 | 42 ± 15 |
| --- | ----- | Ariz. | Jokake C L | 59.1 | 59.4 | 65.7 | 70.6 | 2.90 | 3.71 | 87.5 | 9.0 | 405 ± 5.5 |

Table 5. Summary of Uniform Wheat Experiments, 1952

| Ref. No. | Soil No. | State | Soil Type | Grain Yields (Bu./A) for Application of $P_2O_5$ - Lbs./A: 0 | 20 | 40 | 80 | LSD | Coeff. of Var. Percent | Percent Yield | Percent P in Plants Derived from Fertilizer Applied at 40 Lbs. $P_2O_5$/A | 'A' Value Lbs. $P_2O_5$/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 108 | 52603 | Ore. | Greenleaf or Owyhee Si L | 68.2 | 74.6 | 64.4 | 73.8 | N.S. | 10.4 | ----- | 22 | 144 ± 28 |
| 115 | 52583 | Minn. | Fargo Si C L | 16.2 | 22.1 | 20.5 | 22.0 | 3.2 | 13.0 | 85.8 | 36 | 77 ± 28 |
| 117 | 52586 | " | Barnes L | 21.9 | 21.1 | 18.7 | 18.2 | 2.7 | 10.9 | ----- | 15 | 296 ± 242 |

Table 6. Yields and Percent Phosphorus as Determined by Greenhouse Experiments

| Ref. No. | Soil No. | State | Soil Type | Yield of Millet (gms./pot)[2/] for Application of $P_2O_5$ - Lbs. Per Acre 0 | 40 | 80 | 160 | Percent Yield | Percent $P^{31}$ in Plants for Application of $P_2O_5$ - Lbs. Per Acre 0 | 40 | 80 | 160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 101 | 52604 | Wash. | Sagemoor L | 18.33 | 20.07 | 21.62 | 22.74 | 80.6 | .085 | .096 | .106 | .153 |
| 102 | 52585 | Mont. | Nunn C L | 5.11 | 16.08 | 20.65 | 30.88 | 16.5 | .152 | .097 | .088 | .097 |
| 103 | 52598 | Colo. | Cass Si L | 6.97 | 9.50 | 13.77 | 18.41 | 37.9 | .117 | .142 | .127 | .136 |
| 104 | 52599 | " | Ft. Collins L | 24.78 | 24.02 | 25.41 | 27.23 | ---- | .122 | .120 | .130 | .144 |
| 105 | 52592 | Idaho | Declo L | 0.51 | 9.60 | 17.72 | 21.79 | 2.3 | .224 | .134 | .094 | .102 |
| 106 | 52588 | Cal. | Holtville Si C | 5.04 | 12.83 | 16.03 | 21.50 | 23.4 | .183 | .120 | .087 | .090 |
| 107 | 52602 | Oregon | Olympic Si L | 4.46 | 8.78 | 12.79 | 18.42 | 24.2 | .139 | .121 | .092 | .103 |
| 108 | 52603 | " | Greenleaf or Owyhee Si L | 19.61 | 20.82 | 22.19 | 24.42 | 80.3 | .092 | .098 | .116 | .147 |
| 109 | 52569 | N. Dak. | Cheyenne F S L | 10.02 | 15.50 | 17.01 | 18.23 | 55.0 | .084 | .097 | .122 | .177 |
| 110 | 52570 | " " | Huff L | 3.65 | 14.00 | 18.27 | 20.60 | 17.7 | .171 | .123 | .110 | .098 |
| 111 | 52574 | " " | Timmer L | 16.95 | 18.06 | 20.13 | 21.91 | 77.4 | .080 | .093 | .104 | .145 |
| 112 | 52575 | " " | Langdon L | 16.02 | 20.49 | 22.92 | 23.50 | 68.2 | .084 | .094 | .105 | .145 |
| 113 | 52571 | S. Dak. | Frankfort Si L | 23.90 | 23.84 | 24.23 | 25.30 | ---- | .095 | .105 | .131 | .178 |
| 114 | 52572 | " " | Beadle Si L | 22.08 | 22.15 | 22.45 | 23.01 | ---- | .097 | .112 | .131 | .163 |
| 115 | 52583 | Minn. | Fargo Si C L | 6.50 | 16.60 | 22.99 | 26.20 | 24.8 | .130 | .105 | .100 | .118 |
| 116 | 52584 | Miss. | Ecru Si L | 9.10 | 14.48 | 18.60 | 20.12 | 45.2 | .114 | .093 | .083 | .086 |
| 117 | 52586 | Minn. | Barnes L | 14.43 | 19.87 | 23.44 | 25.62 | 56.3 | .099 | .085 | .082 | .105 |
| 118 | 52576 | Mich. | Hillside S L | 13.01 | 18.43 | 19.74 | 22.26 | 58.5 | .879 | .090 | .092 | .104 |
| 119 | 52577 | Neb. | Sharpsburg Si C | 13.54 | 19.90 | 19.29 | 22.45 | 60.3 | .106 | .090 | .091 | .109 |
| 120 | 52578 | " | Moody Si L | 14.70 | 24.52 | 26.68 | 29.86 | 49.2 | .094 | .074 | .091 | .120 |
| 121 | 52579 | " | Holdrege Si L | 22.13 | 23.18 | 21.69 | 21.67 | ---- | .123 | .145 | .173 | .195 |
| 122 | 52565 | Iowa | Monona Si L | 4.16 | 10.36 | 13.08 | 16.35 | 25.4 | .185 | .130 | .097 | .089 |
| 123 | 52566 | " | Seymour Si L | 1.83 | 9.12 | 14.51 | 17.97 | 10.2 | .147 | .105 | .094 | .092 |
| 124 | 52567 | " | Edina Si L | 2.54 | 10.75 | 15.25 | 19.44 | 13.1 | .150 | .140 | .109 | .102 |
| 125 | 52568 | " | Carrington Si L | 1.89 | 9.61 | 14.82 | 18.78 | 10.1 | .156 | .118 | .104 | .103 |
| 126 | 52589 | Ill. | Muscatine Si L | 2.68 | 8.61 | 13.50 | 17.37 | 15.4 | .122 | .118 | .101 | .096 |
| 127 | 52590 | " | Elliott Si L | 2.30 | 11.40 | 16.10 | 18.79 | 12.2 | .152 | .110 | .115 | .108 |
| 128 | 52600 | Maine | Merrimac S L | 10.81 | 10.80 | 13.40 | 16.35 | 66.1 | .103 | .082 | .074 | .068 |
| 129 | 52601 | " | Caribou S L | 22.68 | 22.08 | 23.54 | 22.64 | ---- | .135 | .153 | .146 | .158 |

continued -

Table 6. Yields and Percent Phosphorus as Determined by Greenhouse Experiments continued -

| Ref. No. | Soil No. | State | Soil Type | Yield of Millet (gms./pot)[2] for Application of $P_2O_5$ Lbs. Per Acre: 0 | 40 | 80 | 160 | Percent Yield | Percent $P^{31}$ in Plants for Application of $P_2O_5$ - Lbs. Per Acre: 0 | 40 | 80 | 160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130 | 52593 | N.C. | Norfolk F S L | 6.01 | 16.32 | 18.18 | 20.86 | 28.8 | .133 | .098 | .095 | .136 |
| 131 | 52573 | S.C. | Cecil S L (Eroded Phase) | .35 | 6.38 | 9.95 | 16.22 | 2.2 | .149 | .107 | .083 | .080 |
| 132 | 52597 | Ala.[1] | Norfolk L S | ---- | ---- | ---- | ---- | ---- | .195 | .146 | .100 | .308 |
| 133 | 52581 | Ga. | Lloyd C L | 12.80 | 13.50 | 14.36 | 15.69 | 81.6 | .0947 | .1012 | .1160 | .1260 |
| 134 | 52582 | " | Orangeburg S L | 12.47 | 17.32 | 18.51 | 20.41 | 61.1 | .1043 | .0812 | .0926 | .1137 |
| 135 | 52587 | " | Madison S L | 12.19 | 13.58 | 15.04 | 19.61 | 62.2 | .1523 | .1497 | .1173 | .1037 |
| 136 | 52580 | Texas | Houston C | 6.04 | 16.09 | 19.24 | 23.91 | 25.3 | .0979 | .0943 | .1043 | .1076 |
| 137 | 52591 | " | Norwood Si C L | 3.95 | 8.12 | 14.69 | 20.38 | 19.4 | .1385 | .1200 | .0853 | .0796 |
| 138 | 52595 | Va. | Davidson C L (Low $P_2O_5$) | .22 | 3.66 | 9.38 | 17.40 | 1.3 | .0929 | .0818 | .0565 | .0639 |
| 139 | 52596 | " | Davidson C L (Med. $P_2O_5$) | 13.00 | 16.67 | 20.33 | 21.71 | 59.9 | .1290 | .0828 | .0910 | .1013 |
| 140 | 52594 | Md. | Chester L | 1.99 | 10.19 | 17.12 | 22.94 | 8.7 | .1307 | .1070 | .0843 | .0769 |

[1] No yield data available - Pots overgrown with weeds.

[2] L.S.D. for comparing 2 levels $P_2O_5$ in the same soil. 5% = 2.44; 1% = 3.21.

Table 7. Frequency Distribution of Percent Yield

| Percent Yield | Frequency |
|---|---|
| 0-20 | 12 |
| 20-40 | 7 |
| 40-60 | 6 |
| 60-80 | 6 |
| 80-100 | 3 |

ouse,

| 205 - Lbs./A ed |
|---|
| y1/ N. C.2/ |
| 675 |
| 125 |
| 12 |
| 12 |
| 8 |
| 7 |
| 16 |
| 437 |
| 239 |
| 62 |
| 115 |
| 25 |
| 115 |
| 64 |
| 9 |
| 26 |
| 44 |
| 57 |
| 55 |
| 92 |
| 240 |
| 159 |
| 10 |
| 13 |
| 11 |
| 14 |
| 11 |
| 60 |
| 212 |

Table 8. Percent Phosphorus in the Crop Derived from the Fertilizer Determined in the Greenhouse, 'A' Values, and Laboratory Determination of Available Phosphorus - continued -

| Ref. No. | Soil No. | State | Soil Type | Percent P in Plants Derived from Fertilizer for Applications of $P_2O_5$ - Lbs. Per Acre | | 'A' Value - Lbs. $P_2O_5$/A Calculated from $P_2O_5$ Applications | | Available $P_2O_5$ - Lbs/A Method | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 40 | 160 | 40 | 160 | Truog | Bray 1/ | N. C. 2/ |
| 130 | 52593 | N.C. | Norfolk F S L | 27.66 | 58.23 | 105 | 115 | 78 | 4 | 58 |
| 131 | 573 | S.C. | Cecil S L (Eroded Phase) | 63.75 | 82.77 | 23 | 33 | 4.6 | 9 | 9 |
| 132 | 597 | Ala. | Norfolk L S | 32.32 | 66.35 | 84 | 81 | 50 | 25 | 49 |
| 133 | 581 | Ga. | Lloyd C L | 20.10 | 46.11 | 159 | 187 | 92 | 60 | 51 |
| 134 | 582 | " | Orangeburg S L | 27.18 | 57.07 | 107 | 120 | 55 | 53 | 43 |
| 135 | 587 | " | Madison S L | 27.69 | 56.87 | 104 | 121 | 69 | 35 | 36 |
| 136 | 580 | Texas | Houston C | 44.50 | 69.28 | 50 | 71 | 37 | 8 | 8 |
| 137 | 591 | " | Norwood Si C L | 23.56 | 57.32 | 130 | 119 | 78 | 30 | 6 |
| 138 | 595 | Va. | Davidson C L (Low $P_2O_5$) | 54.94 | 76.00 | 33 | 51 | 23 | 7 | 8 |
| 139 | 596 | " | Davidson C L (Med. $P_2O_5$) | 18.39 | 46.77 | 178 | 182 | 96 | 28 | 23 |
| 140 | 594 | Md. | Chester L | 37.04 | 71.22 | 68 | 15 | 28 | 7 | 11 |

1/ Determined by the Iowa State Soil Testing Laboratory.

2/ Determined by the North Carolina Soil Testing Laboratory.

Table 9. Soil Analysis Data

| Ref. No. | Soil No. | State | Soil Type | pH | Moisture Equiv. | C | Mechanical Analysis Size, Class and Diameter of Particles (mm.) Very Coarse Sand 2-1 | Coarse Sand 1-0.5 | Medium Sand 0.5-0.25 | Fine Sand 0.25-0.1 | Very Fine Sand 0.1-0.05 | Silt 0.05-0.002 | Clay <0.002 | Weight of Soil Per Pot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Lbs. |
| 101 | 52604 | Wash. | Sagemoor L | 7.5 | 14.5 | 0.64 | 0.5 | 1.4 | 2.7 | 22.1 | 36.4 | 29.8 | 7.1 | 7.4 |
| 102 | 52585 | Mont. | Nunn C L | 7.8 | 27.4 | 2.61 | 0.1 | .4 | 1.4 | 9.6 | 9.4 | 39.5 | 39.6 | 7.2 |
| 103 | 52598 | Colo. | Cass Si L | 7.9 | 23.2 | 1.18 | 1.7 | 1.8 | 1.8 | 15.3 | 24.9 | 28.2 | 26.3 | 7.7 |
| 104 | 52599 | " | Ft. Collins L | 8.0 | 19.1 | .78 | 3.0 | 4.9 | 4.7 | 13.5 | 20.9 | 30.1 | 22.9 | 7.7 |
| 105 | 52592 | Idaho | Declo L | 8.1 | 18.5 | .76 | 0.2 | 4.5 | 6.1 | 11.1 | 10.0 | 53.8 | 14.3 | 7.9 |
| 106 | 52588 | Cal. | Holtville Si C | 8.0 | 25.2 | 1.58 | 0.1 | 0.1 | 0.2 | 1.4 | 9.2 | 49.6 | 39.4 | 7.8 |
| 107 | 52602 | Oregon | Olympic Si L | 5.5 | 27.9 | 2.90 | 2.5 | 3.2 | 1.9 | 4.0 | 4.3 | 57.3 | 26.8 | 7.2 |
| 108 | 52603 | " | Greenleaf or Owyhee Si L | 7.2 | 26.7 | 1.11 | 0.0 | 0.1 | 0.3 | 0.6 | 8.2 | 69.3 | 21.5 | 7.1 |
| 109 | 52569 | N.Dak. | Cheyenne F S L | 6.6 | 14.7 | 1.07 | 0.6 | 1.4 | 6.0 | 33.8 | 20.8 | 25.5 | 11.9 | 7.9 |
| 110 | 52570 | " " | Huff L | 7.9 | 29.1 | 2.04 | 0.1 | 0.1 | 0.7 | 4.0 | 12.9 | 54.6 | 27.6 | 7.2 |
| 111 | 52574 | " " | Timmer L | 5.9 | 21.2 | 1.84 | 0.0 | 1.0 | 8.6 | 32.9 | 9.1 | 29.2 | 19.2 | 7.8 |
| 112 | 52575 | " " | Langdon L | 5.8 | 37.0 | 3.97 | 2.7 | 5.9 | 6.4 | 13.1 | 7.4 | 40.9 | 23.6 | 6.1 |
| 113 | 52571 | S.Dak. | Frankfort Si L | 6.8 | 32.6 | 3.30 | 0.6 | 0.5 | 0.7 | 1.9 | 6.7 | 64.2 | 25.4 | 6.2 |
| 114 | 52572 | " " | Beadle Si L | 6.0 | 29.7 | 2.69 | 1.3 | 2.6 | 3.8 | 8.0 | 5.5 | 47.9 | 30.9 | 6.6 |
| 115 | 52583 | Minn. | Fargo Si C L | 7.8 | 30.3 | 4.27 | 0.3 | 0.4 | 0.7 | 1.8 | 15.6 | 40.8 | 40.4 | 6.7 |
| 116 | 52584 | Miss. | Ecru Si L | 5.8 | 15.7 | 1.15 | 1.1 | 5.5 | 3.4 | 4.6 | 2.3 | 68.6 | 14.5 | 7.8 |
| 117 | 52586 | Minn. | Barnes L | 7.4 | 29.5 | 4.47 | 1.2 | 2.6 | 3.5 | 9.0 | 7.2 | 43.6 | 32.9 | 6.7 |
| 118 | 52576 | Mich. | Hillside S L | 5.4 | 14.1 | 2.06 | 1.3 | 4.0 | 8.5 | 39.1 | 11.9 | 28.1 | 7.1 | 8.4 |
| 119 | 52577 | Neb. | Sharpsburg Si C | 5.8 | 29.8 | 2.17 | 0.0 | 0.0 | 0.2 | 0.5 | 3.9 | 57.8 | 37.6 | 8.2 |
| 120 | 52578 | " | Moody Si C | 5.8 | 30.7 | 2.38 | 0.0 | 0.1 | 0.2 | 0.4 | 7.1 | 53.6 | 38.6 | 6.7 |
| 121 | 52579 | " | Holdrege Si L | 5.8 | 19.1 | 1.82 | 0.0 | 0.1 | 0.4 | 3.0 | 39.6 | 39.2 | 17.7 | 7.3 |
| 122 | 52565 | Iowa | Monona Si L | 7.2 | 26.1 | 1.14 | 0.1 | 0.1 | 0.2 | 0.4 | 4.2 | 72.0 | 23.0 | 7.8 |
| 123 | 52566 | " | Seymour Si L | 5.6 | 30.2 | 1.95 | 0.7 | 1.1 | 0.7 | 0.7 | 0.6 | 66.5 | 29.7 | 7.8 |
| 124 | 52567 | " | Edina Si L | 5.2 | 28.0 | 1.56 | 0.3 | 0.4 | 0.2 | 0.2 | 0.4 | 73.7 | 24.8 | 7.8 |
| 125 | 52568 | " | Carrington Si L | 5.1 | 14.2 | 1.08 | 3.6 | 17.1 | 17.1 | 17.3 | 4.6 | 29.0 | 11.3 | 8.9 |
| 126 | 52589 | Ill. | Muscatine Si L | 5.1 | 23.1 | 1.58 | 0.0 | 0.1 | 0.2 | 0.4 | 2.8 | 74.6 | 21.9 | 6.6 |
| 127 | 52590 | " | Elliott Si L | 5.0 | 26.1 | 2.18 | 0.2 | 0.8 | 1.0 | 1.6 | 1.5 | 66.5 | 28.4 | 6.1 |
| 128 | 52600 | Maine | Merrimac S L | 5.9 | 15.6 | 2.23 | 0.4 | 2.0 | 2.1 | 7.3 | 35.6 | 44.8 | 7.8 | 6.6 |
| 129 | 52601 | " | Caribou S L | 5.0 | 28.1 | 1.90 | 4.5 | 5.1 | 3.5 | 7.5 | 10.1 | 52.3 | 17.0 | 7.2 |

continued -

Table 9. Soil Analysis Data - continued -

| Ref. No. | Soil No. | State | Soil Type | pH | Moisture Equiv. | C | Mechanical Analysis Size, Class and Diameter of Particles (mm.) Very Coarse Sand 2-1 | Coarse Sand 1-0.5 | Medium Sand 0.5-0.25 | Fine Sand 0.25-0.1 | Very Fine Sand 0.1-0.05 | Silt 0.05-0.002 | Clay <0.002 | Weight of Soil Per Pot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Lbs. |
| 130 | 52593 | N.C. | Norfolk F S L | 6.4 | 5.8 | 0.28 | 6.5 | 21.4 | 16.3 | 25.3 | 12.7 | 13.5 | 4.3 | 9.5 |
| 131 | 52573 | S.C. | Cecil S L (Eroded Phase) | 6.6 | 14.6 | 0.79 | 7.9 | 19.0 | 12.4 | 19.2 | 6.6 | 19.3 | 15.6 | 7.9 |
| 132 | 52597 | Ala. | Norfolk L S | 5.2 | 4.6 | 0.35 | 1.2 | 25.9 | 30.2 | 22.1 | 5.4 | 12.3 | 2.9 | 6.6 |
| 133 | 52581 | Ga. | Lloyd C L | 5.6 | 14.8 | 1.52 | 3.8 | 14.2 | 11.7 | 21.4 | 6.3 | 21.6 | 21.0 | 6.9 |
| 134 | 52582 | " | Orangeburg S L | 5.0 | 8.2 | 1.44 | 1.7 | 6.2 | 8.2 | 40.7 | 20.0 | 17.4 | 5.8 | 7.4 |
| 135 | 52587 | " | Madison S L | 5.8 | 16.0 | 2.28 | 11.7 | 19.1 | 11.4 | 15.8 | 6.1 | 20.5 | 15.4 | 7.4 |
| 136 | 52580 | Texas | Houston C | 6.6 | 30.9 | 2.72 | 2.4 | 1.9 | 0.6 | 0.6 | 0.5 | 45.9 | 48.1 | 6.4 |
| 137 | 52591 | " | Norwood Si C L | 8.2 | 18.9 | 0.44 | 0.1 | 0.1 | 0.4 | 0.9 | 17.0 | 60.3 | 21.2 | 8.3 |
| 138 | 52595 | Va. | Davidson C L (Low $P_2O_5$) | 5.4 | 25.2 | 1.20 | 2.3 | 3.6 | 2.0 | 2.9 | 2.3 | 45.3 | 41.6 | 6.3 |
| 139 | 52596 | " | Davidson C L (Med. $P_2O_5$) | 6.0 | 31.0 | 2.30 | 3.1 | 2.9 | 1.8 | 3.3 | 3.0 | 42.6 | 43.3 | 5.9 |
| 140 | 52594 | Md. | Chester L | 4.8 | 21.9 | 1.39 | 0.5 | 3.1 | 5.2 | 11.0 | 6.0 | 54.0 | 20.2 | 6.8 |

Table 10. Correlations of Yield Response with Selected Methods for Determining Availble Phosphorus

| | r | $r^2$ |
|---|---|---|
| Percentage yield for field experiments with- | | |
| 'A' value 1/ | .51 | .26 |
| Bray Method 2/ | .04 | .002 |
| Truog Method 2/ | .30 | .09 |
| Percentage yield 3/ for greenhouse experiments with- | | |
| N. C. State laboratory method | .50 | .25 |
| 'A' value | .80 | .64 |
| Bray method | .75 | .56 |
| Truog method | .41 | .17 |

1/ n = 15
2/ n = 13
3/ n = 34

Table 11. Simple and Multiple Correlations Involving Percent Yield Determined in the Greenhouse

| Percentage Yield Correlated with - | r | R |
|---|---|---|
| 'A' value | .80 | |
| Bray method | .75 | |
| Bray method + 'A' value | | .84 |
| Maximum yield | .15 | |
| Maximum yield + 'A' value | | .81 |
| Maximum yield + Bray method | | .76 |
| Yield of check | .96 | |
| Yield of check + 'A' value | | .98 |

Table 12. Correlations of 'A' Value Determined in the Greenhouse with Available Phosphorus by Laboratory Methods

| 'A' Value (n = 40) with | r | $r^2$ | R | $R^2$ |
|---|---|---|---|---|
| Bray method | .94 | .87 | | |
| N. C. State laboratory method | .22 | .05 | | |
| Truog method | .23 | .05 | | |
| Truog method + pH | | | .44 | .19 |